Food and Agriculture Organization of the United Nations

World Health Organization

Joint FAO/WHO Expert Meeting on Microbiological Risk Assessment (JEMRA) on the Prevention and Control of Microbiological Hazards in Fresh Fruits and Vegetables

Part 1: Administrative procedures, meeting scope/objectives, data collection
(Virtual meeting, 26 and 28 July 2021)

Part 2: General principle and fresh fruits and vegetables
(Virtual meeting, 20 September – 1 October and 4 October 2021)

SUMMARY AND CONCLUSIONS

Issued on 22 November 2021

The virtual JEMRA meetings on the Prevention and Control of Microbiological Hazards in Fresh Fruits and Vegetables (Part 1 and Part 2) were convened to provide scientific advice on the general principles and relevant measures for control of microbiological hazards in fresh, ready-to-eat and minimally processed fruits and vegetables, including leafy vegetables, from primary production to point-of-sale.

If conditions had permitted, this meeting would have been held at FAO headquarters in Rome, Italy. Because of the travel restrictions and lockdowns due to the COVID-19 pandemic in many countries, the joint FAO/WHO secretariat was unable to convene a physical meeting. Therefore, the meeting was held as a videoconference using a virtual online platform.

Dr Elizabeth A. Bihn served as Chairperson.

Dr Pascal Delaquis served as rapporteur.

Subsequent meetings of JEMRA on the Prevention and Control of Microbiological Hazards in Fresh Fruits and Vegetables (2021-2022) will focus on sprouted seeds and other commodity-specific recommendations.

This document summarizes the conclusions of the Part 1 and Part 2 meetings and is made available to facilitate the deliberations of the upcoming Codex Committee on Food Hygiene (CCFH). The full report will be published as part of the FAO and WHO Microbiological Risk Assessment (MRA) Series.

The meeting participants are listed in Annex 1 of this summary report.

More information on this work is available at:

http://www.fao.org/food-safety/en/

and

https://www.who.int/foodsafety/en/

1. Introduction

1.1 Background

Fresh fruits and vegetables are an important part of a healthy diet and are protective against many chronic health conditions. Yet, fresh fruits and vegetables are increasingly being implicated in food safety incidents involving microbiological hazards around the globe. Fresh produce contaminated with food-borne pathogens (e.g. bacteria, viruses, protozoa, helminths) have resulted in numerous outbreaks of food-borne disease and trade disruptions (Carstens *et al*., 2019; Lynch *et al*., 2009; de Oliveira Elias *et al*., 2018).

The Codex Alimentarius Commission (CAC) initially developed the "Code of Hygienic Practice for Fresh Fruits and Vegetables" in 2003 then later revised it following a JEMRA meeting, held in 2008, to address microbiological hazards associated with leafy vegetables and herbs (FAO and WHO, 2008). Several commodity specific annexes were added to the code of practice in 2012, 2013, and 2017 (FAO and WHO, 2017).

Subsequently, in 2018, FAO and WHO published the report Shiga toxin-producing *Escherichia coli* (STEC) and food: attribution, characterization and monitoring (MRA31) (FAO and WHO, 2018a) wherein fresh fruits and vegetables were identified as important sources of STEC infections. In 2019, following a request from the CCFH, the CAC approved new work at its 42nd Session on the development of guidelines for the control of STEC in leafy greens and in sprouts (FAO and WHO, 2018b). More recently, in October 2020, a JEMRA meeting on *Listeria monocytogenes* in Ready-to-Eat (RTE) Foods noted increased reports of listeriosis acquired from fresh and minimally processed fruits and vegetables (FAO and WHO, 2020).

To meet the requests of the CCFH and to update and expand the information available in MRA14, FAO and WHO convened a series of expert meetings on preventing and controlling microbiological hazards in fresh fruits and vegetables. The goal of these meetings was to gather recent data, evidence, and provide scientific opinions on the topic.

1.2 Objectives

The purpose of the meetings was to collect, review and discuss relevant measures for control of microbiological hazards from primary production to point-of-sale in fresh, ready-to-eat, and minimally processed fruits and vegetables, including leafy vegetables.

The scope of the meetings included aspects of primary production in open fields or in protected facilities (such as high and low tunnels, production under cover, greenhouses and net houses and address hydroponic and aquaponic systems and other systems as required) and post-harvest activities, including activities performed prior to packing, minimal processing, distribution, maintenance of the cold chain where applicable, transportation and handling at point-of-sale. Emphasis was placed on the identification and evaluation of solutions to reduce microbiological risks that result in food-borne illnesses associated with fresh fruits and vegetables produced in various regions of the world, taking into consideration their effectiveness and suitability.

Regulatory expectations and limitations of individual countries were not the focus of the meeting. It is understood that individual country regulations may not align with the definitions provided in this report,

but it is expected that the information presented will still be useful and can advance the understanding of hazards and risk mitigation.

The objectives of the meetings included:

- To identify and characterize fresh fruits and vegetables and microbiological hazard combinations of concern to public health.
- To review publicly available literature and guidelines from competent authorities and industry associations (e.g. compliance guidelines, code of practices) to assess the current state of knowledge regarding the control of microbiological hazards in fresh fruits and vegetables. Effort was made to increase understanding of hazards and their control in areas where reporting is not common. To this end, unpublished data from reputable researchers were included in this assessment, especially from countries that lack surveillance systems.
- To review mitigation/intervention measures being used at different points along the food continuum (e.g. pre-harvest to market and point-of-sale) and assess their effectiveness at reducing microbiological hazards.

1.3 Glossary of terms

Fruits and vegetables: Fruits and vegetables, including leafy vegetables and herbs, are considered as edible parts of plants (e.g. seed bearing structures, flowers, buds, leaves, stems, shoots and roots), either cultivated or harvested wild, including fungi. (Modified by FAO, 2021)

Exclusions from this definition and this document include, but are not limited to:

- Starchy root and stem tubers such as cassavas, potatoes, sweet potatoes and yams (although leaves of these plants consumed as vegetables are included)
- Dry grain legumes (pulses) unless harvested when immature
- Cereals including corn, unless harvested when immature
- Nuts, seeds and oilseeds such as coconuts, walnuts, sunflower seeds
- Medicinal plants, unless used as vegetables
- Macroalgae
- Spices
- Stimulants such as tea, cacao and coffee
- Processed and ultra-processed products made from fruits and vegetables such as alcoholic beverages (e.g. wine, spirits), plant-based meat substitutes or fruit and vegetable products with added ingredients (e.g. packed fruit beverage, ketchup)

Fresh (fruits and vegetables): Fruits and vegetables that are not processed in a manner that changes their physical properties. Cooked, canned, juiced, frozen, candied, dried, pickled, fermented or otherwise preserved foods derived from fruits and vegetables are excluded from this definition and this report.

Ready-to-eat (fruits and vegetables, including minimally processed): Fruits and vegetables intended for direct human consumption without any additional steps or action taken to reduce or eliminate microbial contamination (Modified by FAO and WHO, 2017).

Minimally processed (fruits and vegetables): Fruits and vegetables that have undergone processes that do not affect their fresh-like quality, such as washing, trimming and cutting (Modified from FAO, 2021).

Fruits and vegetables that are peeled, cut into pieces, chopped, frozen or dried, with the exception of leafy vegetables, are not included in this report.

Microbiological hazard: Food-borne microbiological hazards include, but are not limited to, pathogenic bacteria, viruses, algae, protozoa, fungi, parasites, prions, toxins and other harmful metabolites of microbiological origin (FAO and WHO, 2013).

1.4 Modeling of microbiological risks in fresh produce

Mathematical models and tools for the microbiological risk assessment, including predictive microbiological models for growth/inactivation that can be used for risk assessment have been developed in recent years. Examples are included in the full report.

2. Fresh, ready-to-eat, and minimally processed fruits and vegetables

2.1 Food-borne illness

The experts noted that surveillance and outbreak data from many countries, including developing nations, is generally sparse, if not missing all together. Such data are needed to more accurately assess the burden of illnesses associated with fresh fruits and vegetables and to identify salient causes of contamination for food. All data are useful, including illness, outbreak and recall data from research or other sources, and effort was placed on gathering this information. The experts sought to update and include any recent trends in commodity and pathogen pairing and pathogen occurrence and presence.

2.2 Microbiological hazards

The experts developed tables to collect microbiological hazard, commodity, year, country, cases, level of contamination, region and references to update data. It was decided that pathogens would not be ranked due to the lack of illness and outbreak data for so many countries and regions. Effort was focused on collecting information from as many countries as possible to expand the understanding of new, emerging, re-emerging or neglected pathogens and commodity-pathogen pairings, as well as practices that may be contributing to increased illnesses.

2.3 Commodities of concern

The experts concluded that some commodities such as leafy vegetables, herbs, sprouts and cantaloupes (rock melons) remain leading causes of produce-associated infections but noted that any commodity can become contaminated, as demonstrated by a recent outbreak involving bulb onions (FDA, 2021). It was also noted that bias may be introduced by under-reporting from some countries, and that some commodities may not yet be recognized as vehicles for the transmission of food-borne pathogens given limitations to the current food-borne illness surveillance programs.

2.4 Overview of production systems

It is recognized that a range of production systems (e.g. conventional, organic, urban, peri-urban agriculture, less-defined systems) exist in highly diverse geographic regions with varying environmental conditions, fauna and climate subjected to extreme events and changing patterns due to changing

climate. Variable market channels, distribution networks, cultural practices, consumption patterns and regulatory frameworks influence specific risks that may be associated with them. This report provides examples, but it is understood that each grower should employ a food safety management system, including microbiological risk assessments, and plan for extreme weather events relevant to their location. There are universal practices and resources required for food safety, including sanitary facilities, personal hygiene, training and sanitation that are critical to risk reduction, which should be adopted in all production systems. In the field environment, Good Agricultural Practices (GAPs) and Good Hygienic Practices (GHPs) are recommended. As production moves into partially or fully enclosed facilities, Good Manufacturing Practices (GMPs) become practical and as minimal processing occurs, operations should consider application of the Hazard Analysis Critical Control Points (HACCP) system.

2.5 International production and trade

International trade requirements should be based on validated practices that reduce microbiological risks. Many audit schemes, certifications, private standards and other trade requirements have moved beyond food safety and are not relevant to microbiological risk reduction. It is also important that food grown for domestic markets also be produced with food safety practices to reduce risks to local consumers. It is a concern that food safety practices are prioritized for commodities that enter international trade and abandoned for commodities destined for local or domestic markets. Public health requires that all fresh fruits and vegetables be produced in a safe manner.

3. Primary production in open fields

3.1 Location, adjacent land use, topography, and climate

Climate and weather (including local variability and extreme weather events related to the changing climate), topography, geographic location and adjacent land use can influence the magnitude and frequency of transfer of microbiological hazards from environmental sources to growing crops. Some geographical locations are clearly more at risk from climate related events. Measures can be applied to mitigate such risks, for example intercropping, crop rotation, water management through suitable drainage, and the establishment of buffers and barriers. However, the experts recognized that there are significant data gaps, which preclude accurate assessment of both the magnitude of the risks and the efficacy of strategies for their mitigation. The full report will include details about the scope and impact of these factors on the potential transmission of microbiological hazards to fruit and vegetables including leafy vegetables.

3.2 Prior land use and assessment

Use of land for human settlement, animal rearing, industrial activities, open defecation and sewage and waste disposal as well as drift from adjacent agricultural activity introduces microbiological hazards that may persist in the growing environment. The experts noted that it is critical to perform a risk assessment to determine the most appropriate mitigation steps. Mitigation steps could include crop rotation, fallowing, improvements in infrastructure including drainage and longer-term considerations such as landscape planning. However, there is lack of data concerning long-term survival of microbiological hazards in land used for purposes other than growing fruit and vegetable crops.

3.3 Unintentional contact of crops with contaminated water

Unintentional contact of crops with contaminated water due to numerous causes, such as extreme weather events, which cause flooding from streams, rivers and canals, can introduce microbiological hazards to the production environment. There is insufficient data in this area, but some mitigation strategies can be applied to minimize the occurrence. These include land management practices such as sloping to lessen water intrusion, pumping into deep wells or other underground storage, barrier construction along water bodies and creating drainage channels, trenches or drain tiles.

3.4 Wildlife, livestock, and human intrusion

Wildlife, livestock and humans are a part of the environment, but also can introduce microbiological hazards through faeces as well as distribute microbial hazards via field intrusion. Risk mitigation steps can include practical applications such as harvest buffers and pre-harvest inspections, and physical interventions such as fences. The experts noted there are a wide variety of species, cultural practices including integrated livestock and produce production systems, and various human activities that impact risks. Risk assessment must include identifying most likely risks from geographically relevant wildlife, livestock, cultural practices, and human intrusion as well.

3.5 Water quality

Water applied to crops can impact the microbiological safety of fruits and vegetables. The experts recognized that water of highly variable microbiological quality is used in crop production, for numerous agricultural activities, during production, handling and/or processing and it may adversely affect produce safety. Experts also recognized that sometimes water can unintentionally contact crops through equipment malfunction (e.g. broken pipes, sprinkler heads) or flooding caused from over-pumping during irrigation. The public health impact of these events can be assessed if something is known about water quality, hence water testing is recommended to assess water quality, with the option of treatment to ensure fit-for-purpose water. However, other strategies that decrease risks can be applied, such as irrigation methods that limit contact with the harvestable portion of the crop.

3.6 Soil amendments (animal manures, biosolids and other natural fertilizers)

Application of untreated animal and human manures to soil used to grow fruits and vegetables results in significant microbiological risks. Extending the time between application and harvest reduces risks, but best practice is to avoid contact of all soil amendments with the harvestable portion of the crop, minimize run-off into waterways and avoid crop contamination via dust. Treatment of manures through controlled and validated composting or other processes (e.g. heat treatment) prior to field application will reduce risks.

3.7 Harvest, field packing, and packinghouse packing

This section encompasses an extremely diverse set of practices that could introduce microbiological hazards from humans, food contact surfaces, equipment and water as well as through cross-contamination. Extended time between harvest and consumption and improper cold storage can increase the opportunity for pathogens that may be present to multiply, thereby increasing the likelihood of illness. The experts acknowledged the global diversity of farms and farming practices. Hazards should be assessed

for each farm; however, some control measures should be applied in all settings. Worker education and training are critical to the proper implementation of food safety practices. All farms should have a sanitation program to ensure food contact surfaces and equipment do not introduce microbial hazards. Water that comes into contact with fruits and vegetables at harvest and during post-harvest activities should be fit-for-purpose, with microbiological quality being extremely important for minimizing risks.

4. Primary production in protected facilities

Fresh fruits and vegetables are grown in a range of protected facilities. The full report provides examples of facilities that are considered protected facilities and summarizes relevant risks and mitigation practices that are unique to each. Protected production systems are not inherently safer than open systems. Protected facility structures should be located, designed and constructed to avoid contamination and harborage of pests such as insects, rodents and birds. Worker training and sanitation practices are necessary in all operations. Proper water management and soil amendment use are critical to controlling and reducing risks. Use of GAPs and GHPs are recommended. Each operation should assess specific hazards and implement mitigation practices to reduce risks associated to the identified hazards.

5. Minimally processed

Available research does indicate that several practices can be implemented to identify and reduce microbiological risks. Grading/culling and pre-washing prior to processing, the use of sanitizers to maintain the microbiological quality of processing water and ensuring raw products are separated from final products will reduce cross-contamination during processing. Many data gaps were noted including the effectiveness of washing and use of different sanitizers and the influence of natural microbiota, microbial attachment and infiltration on overall risks. Maintaining the cold chain will reduce multiplication of bacterial pathogens that may persist during processing. GHPs, GMPs and the HACCP system support hazard identification and implementation of effective control practices. As mentioned previously, sanitation and worker training programs are critical steps for reducing microbiological risks.

6. Transport, distribution and point-of-sale

This section covers all steps from field packing, as well as packing in a building, to the point-of-sale. The microbiological risks encountered along this chain include the potential for bacterial growth during transport, distribution and at point-of-sale. Contamination and/or cross-contamination can also be occurred as a result of improper handling during loading and unloading, comingling and displaying with raw commodities and animals/animal products and exposure to unsanitary surfaces and water at point-of-sale. Mitigation strategies include training of operators, produce handlers and retailers, as well as the use of clean, enclosed, refrigerated transport vehicles, a clean and sanitary point of sale environment and fit-for-purpose water for cleaning, sanitizing and cooling. Maintaining cool temperatures will limit growth of bacterial pathogens. Storing produce in cool locations, and moving fruits and vegetables quickly to the

point-of-sale when refrigerated storage is not available can reduce risk. Cold storage is not suitable for some fruits and vegetables, as it may cause product deterioration that may result in bacterial growth. There is a need for additional research to further assess the risks and identify practical mitigation strategies that cover the diversity of transport, cold chain and distribution channels for fresh produce globally.

7. Significant gaps in mitigations/interventions measures

Fruit and vegetable production includes many different commodities grown in diverse geographic regions that are often distributed globally. It is unlikely there will be sufficient research data to clearly identify all hazards or define practices to reduce all associated risks. Acknowledging these challenges, the experts identified research areas that would be most valuable for study in the full report, including both hazard identification and mitigation interventions.

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Annex 1. List of participants

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